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Reappearance of Georges Bank (5Z) herring: a biological update

by

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Abstract

Reappearance of the Georges Bank herring population raises questions of biology (how and where did the recovery start), assessment (how best to quantify recovery) and management. This paper summarizes recent biological and assessment-related information.

The evidence for reappearance is updated, primarily from bottom trawl and plankton research surveys. The scope and extent of relevant Canadian and US research surveys are summarized and potential abundance indices based on larval abundance and bottom trawl catch rates are proposed. A stock identification project which includes samples from Georges Bank is described.

Although there is continued evidence of recovery of the Georges Bank herring population, there is insufficient information on which to base a meaningful estimate of population size.

Résumé

La réapparition de la population de harengs du banc Georges soulève des questions du point de vue de la biologie (où et quand la récupération du stock a-t-elle commence?), de l'évaluation (quelle est la meilleure façon de quantifier cette récupération?) et de la gestion. Le présent article résume certaines informations récentes du point de vue biologique et du point de vue de l'évaluation.

Les indices de cette réapparition sont mis à jour, principalement à l'aide des relevés par chalutage sur le fond et des relevés de recherche portant sur le plancton. La portée et l'étendue des relevés de recherche canadiens et américains pertinents sont résumés et on propose des indices d'abondance possibles fondée sur l'abondance larvaire et les taux de prise par chalutage sur le fond. On décrit un projet d'identification des stocks qui comprend des échantillons provenant du banc Georges.

Bien qu'on continue de trouver des indices d'une récupération de la population de harengs du banc Georges, nous ne disposons pas d'une information suffisante pour procéder à une évaluation significative de la taille de la population.

Introduction

The fishery for herring on Georges Bank (5Z) began in 1961 and grew rapidly. Landings by a multinational fleet using a variety of gear types increased to 374,000 t in 1968 and yielded approximately 2.7 million t before crashing in 1977 (Anthony and Waring 1980).

For several years, there was virtually no sign of either adults (Azarowitz and Grosslein 1987) or larvae (Smith and Johnson 1986) from what had once been estimated to be the largest herring population in the northwest Atlantic. In recent years (since 1984), however, there has been increasing indication of reappearance of Georges Bank herring, including evidence of spawning and substantial number of larvae (Stephenson et al. 1987; Stephenson and Power 1989).

Continued evidence of recovery raises the following biological, assessment and management issues:

1) Biology and stock structure:

   a) Is the reappearance the result of resurgence of a remnant of the original Georges Bank population, or recolonization by a neighboring population?

   b) Why did reappearance begin with the 1983 year-class?

   c) Are there unique biological characteristics associated with the expanding population?

   d) What was/is the relationship of Nantucket Shoals spawners to the Georges Bank population?

2) Assessment and estimation of stock size:

   a) What is the best method of estimating stock size and quantifying the rate of recovery?

   b) What surveys/techniques should be used to quantify and monitor stock status?

3) Advice and management:

   a) What are appropriate management objectives - including clarification of transboundary aspects, contribution to other fisheries (particularly coastal juvenile fisheries) and fishing industry expectations?

In this paper, we:

1) update the chronology of the Georges Bank herring recovery;
2) present and discuss results of recent research surveys;
3) review potential abundance indices; and
4) summarize a stock identification study which includes samples from Georges Bank.

Chronology of the reappearance of herring on Georges Bank

The absence of Georges Bank herring after collapse of the fishery in 1977 was confirmed by larval surveys (e.g. Smith and Johnson 1986) and by-catch records from groundfish surveys (e.g. Azarowitz and Grosslein 1987).

The reappearance is chronicled in Table 1. Evidence has been compiled primarily from directed surveys for larvae (oblique bongo tows) and from the appearance of adult herring as by-catch in both Canadian (Dept. of Fisheries and Oceans - DFO) and U.S. (Northeast Fisheries Center - NEFC) research groundfish surveys, with additional observations from occasional cruises for other species (e.g., juvenile gadid (IYGPT trawl) and larval lobster surveys (bongo)) and the commercial fishery.

The first indication of reappearance was postlarval herring taken by IYGPT trawl in the spring of 1984 (1983 year-class). Research groundfish surveys began picking up prespawning adult herring in the spring of 1986 and the first spawning adults in the fall of 1986; these were almost exclusively of the 1983 year-class. A Canadian purse seiner made one trip to Georges Bank in May 1986 and made sets of 2 and 68 t.

Key information came in the fall of 1986 with the verification of ripe herring in both DFO and NEFC ground trawl surveys of Georges Bank.

A directed survey in the fall of 1987 (Fig. 1a) recorded ripe and recently spent adults, and the presence of significant numbers of larvae, indicating that spawning had been successful.

A DFO survey of both larval and adult herring on Georges Bank was undertaken again between Oct. 30 and Nov. 11, 1988 (Lady Hammond cruise 195; Fig. 1b). Adults were taken opportunistically in ground trawl sets. Tows were made for larvae according to a stratified random design in the area of historical spawning on the Georges Bank (Fig. 2b). At the same time, a collaborative NEFC cruise (Delaware II) surveyed herring larvae on the western portion of Georges Bank, Nantucket Shoals and north of Cape Cod. At one point, the two vessels met for a series of comparative tows. Additional NEFC cruises surveyed herring larvae of the

Georges Bank and Nantucket Shoals area once earlier (October) and twice later (December, January) in the season.

A similar set of cruises in 1989 (Table 1; Fig. 1c, 2c) found both larvae and adult herring.

Results of recent surveys

A) Canadian (DFO) autumn herring surveys: Prior to 1987, surveys of Georges Bank were undertaken as extra stations on the Bay of Fundy larval survey when weather and time permitted. The coverage was limited (Table 2A), but confirmed (with the U.S. Marmap data) the general absence of larvae. Expanded surveys undertaken in early November since 1987 have collected both larvae (using bongo nets) and adults (using ground trawl).

The 1987 larval survey was a fixed station coverage designed to document the location of larvae. The 1988 and 1989 surveys evolved to a stratified random coverage of an area including historical spawning sites to allow calculation of abundance.

Station locations and larval abundance are presented in Fig. 1 and 2. The length frequency distribution of larvae from the 1988 survey was bimodal (Fig. 3) with peaks at 9 and 13 mm, whereas the distribution in 1989 was unimodal with a peak at 11 mm.

Ground trawl sets were made opportunistically to collect postspawning adult herring in order to monitor age distribution. Herring were generally taken along the northern edge of Georges Bank (Fig. 4). Size and age information (Fig. 5) shows the progression of 1983, 1984, 1985 and 1986 year-classes.

B) U.S. (NEFC) autumn larval herring surveys: Prior to 1988, the MARMAP surveys monitored larvae on Georges Bank with broad spatial coverage during late autumn (Nov.-Dec.) (Table 2B).

Since 1988, the NEFC survey effort has been greatly increased, with four larval surveys of Georges Bank and Nantucket Shoals between September and January 1988/89 and again in 1989/90.

C) Canadian (DFO) spring groundfish surveys: Since 1986, a Canadian research survey has sampled between 50 and 100 stations on Georges Bank using a Western IIA bottom trawl and a stratified random sample design. These surveys have been picking up an increasing number of herring as bycatch (Table 2C).

D) U.S. (NEFC) research bottom trawl surveys: NEFC bottom trawl surveys have sampled Georges Bank in the spring (between Feb. and Apr.) since 1968 (Table 2D) and in the autumn (Sept.-Nov.) since 1963 (Table 2E).

Potential abundance indices

We have attempted to derive abundance estimates from both larval and groundfish surveys. An experimental acoustic survey has been planned for the autumn of 1990.

Larval abundance

Results of the DFO larval herring surveys in 1988 and 1989 are summarized in Table 3. Abundance has been calculated for each of the 18 strata, and for the entire survey area. For the 1988 survey, there is also a comparison of port and starboard bongo nets (collected on the same tows) which has not been included here. Two estimates from the larval survey should be investigated:

1) backcalculation of spawning size, and

2) a predictive relationship between historical larval surveys and pre-collapse VPA estimates of population size.

Ground trawl bycatch index

Results of recent NEFC and DFO groundfish surveys are presented in Table 4. Number of herring per set (weighted by stratum) is seen as the most appropriate index and is plotted in Fig. 6. These results reflect the general increase in population size which is believed to have occurred, but should be considered preliminary until possible set, vessel and strata effects have been investigated. The relationship between historical ground trawl survey data and pre-collapse estimates of population size should be investigated.

Stock Identification

This reappearance has raised an obvious question concerning stock affinity - Has it been the result of the original Georges Bank population, or recolonization by fish from a neighboring stock? In a recent paper, Stephenson and Kornfield (1990) have argued that it is resurgence rather than recolonization, on the basis of timing, age composition and biochemical attributes during recovery.

As part of an ongoing effort to define herring stock structure generally, samples from Georges Bank have been included in a comparative study of stock attributes. Approximately 2900 fish from 13 spawning areas (Table 5) are being analyzed for an extensive list of attributes including morphometric and meristic characters and parasite loads, and a limited number for biochemical traits (Table 6).

The study, which is still in progress, differs from most previous studies of this type in that it contains primarily documented spawners ("ripe and running" fish) collected from spawning grounds. The rationale has been that discrete spawning samples would overcome the potential problem caused by stock mixing in many previous studies (where samples were taken from commercial fisheries on fish other than at spawning time). Further, the study involves a multivariate approach (including some new or modified variables) in a field which has traditionally considered single or groups of related attributes.

Analysis of the Georges Bank samples has revealed a few interesting differences in the isozyme PGI-2 (Stephenson and Kornfield 1990) and in prevalence of the parasites of the *Scolex pleuronectis* group. Tables 7 and 8 show results of meristic counts and parasite prevalence in herring from Georges Bank and neighboring groups.

Prognosis

There is continued evidence of recovery of the Georges Bank population, but there is insufficient information at present on which to base a meaningful estimate of population size. Larval surveys have demonstrated successful spawning in recent years and results from ground trawl surveys show recruitment of additional year-classes, but there is no evidence yet of high abundance.

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Table 1. Chronology of the reappearance of herring on Georges Bank.

Date	Observation	Vessel/Location
12 June 1984	Small juveniles (n>200) taken by mid-water (IYGPT) trawl on Canadian research survey. All from 1983 year-class; mean length = 60.5 mm.	R/V Alfred Needler cruise 29 One set at 42°02'N, 66°59'W.
24 Feb. 1986	Adult herring (n=213; non-reproductive) taken by ground trawl on U.S. groundfish survey. All from 1983 year-class.	R/V Delaware cruise 86-02 At four sets around 41°49'N, 66°50'W.
5-12 Mar. 1986	Adult herring (n=786; non-reproductive) taken by ground trawl on Canadian groundfish survey. Length range 15-26 cm (mean = 19.5 cm) indicates 1983 year-class.	R/V Alfred Needler cruise 59 19 sets.
19-20 May 1986	First successful commercial purse seiner catch.	M/V Lady Melissa. Sets of approx. 2 t (42°04'N, 66°30'W) and 68 t (42°05'N, 66°35'W) by purse seine.
14-24 Oct. 1986	Adult herring (n=43; reproductively active) taken by ground trawl on U.S. groundfish survey. All from 1983 year-class.	R/V Albatross cruise 86-05 (II).
29 Oct.- 5 Nov. 1986	Adult herring (n=111; reproductively active) taken by ground trawl on Canadian groundfish survey. Almost entirely 1983 year-class.	R/V Alfred Needler cruise 71 13 sets along 50 fath contour of northeast peak.
3-11 Nov. 1987	Adult herring (n=396; reproductively active) taken by ground trawl, and larvae (in 19 sets; in significant numbers (n>200) in four sets) taken by bongo net in Canadian research survey.	R/V Lady Hammond cruise H 181
30 Oct.- 11 Nov. 1988	Collaborative survey by Canada and U.S. maps larval distribution and abundance. Adult herring taken by ground trawl on western edge of Georges.	R/V Lady Hammond cruise 194; R/V Delaware II cruise 88-12.
3 Oct. 1988- 20 Jan. 1989	Series of U.S. cruise maps changes in larval distribution and abundance on Georges Bank/Nantuucket Shoals.	R/V Albatross IV 88-09(II) R/V Delaware II 88-12 R/V Albatross IV 88-11 R/V Delaware II 89-01
24 Oct.- 9 Nov. 1989	Canadian survey defines larval abundance and adult age composition on Georges Bank.	R/V Lady Hammond 207

Table 1. (cont'd)

Date	Observation	Vessel/Location
2 Oct. 1989- 17 Jan. 1990	Series of U.S. cruises maps changes in larval distribution and abundance on Georges Bank/Nantucket Shoals.	R/V Delaware II 89-06(II,III) R/V Delaware II 89-07 R/V Delaware II 89-09 R/V Delaware II 90-01

Note: Groundfish surveys (spring and fall; Canada and U.S.) have consistently picked up herring since 1987, but are not listed.

Table 2. Summary of Georges Bank survey cruises.

Table 2A. Canadian autumn larval herring cruises.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1984	Nov. 1-15	E.E. Prince	P315	Herring larvae	Georges	7	Bongo
1985	Nov. 2-15	E.E. Prince	P329	Herring larvae	Georges	7	Bongo
1987	Nov. 2-12	Lady Hammond	H181	Herring larvae + adults	Georges	47	Bongo
1988	Oct. 28-Nov. 11	Lady Hammond	H195	Herring larvae + adults	Georges	77	Bongo
1989	Oct. 24-Nov. 9	Lady Hammond	H207	Herring larvae + adults	Georges	94	Bongo

Table 2B. U.S. autumn larval herring cruises.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1983	Nov. 14-Dec. 21	Delaware II	83-09	Marmap	MABGME	152	Bongo
1984	Nov. 1-Dec. 5	Delaware II	84-09	Marmap			Bongo
1985	Nov. 12-Dec. 12	Delaware II	85-10	Marmap	MABGME	180	Bongo
1986	Nov. 3-Dec. 12	Delaware II	86-10	Marmap			Bongo
1987	Nov. 16-Dec. 11	Delaware II	87-10(II,III)	Marmap	Georges/Nantucket	69	Bongo
1988	Sept. 23-Oct. 28	Albatross IV	88-09(II,III)	Autumn bottom trawl	Georges/Nantucket/G of M	85	Bongo
1988	Oct. 31-Nov. 11	Delaware II	88-12	Larval herring	Georges/Nantucket	85[1]	Bongo
1988	Nov. 29-Dec. 10	Albatross IV	88-11	Larval herring	Georges/Nantucket	132	Bongo
1989	Jan. 5-20	Delaware II	89-01	Larval herring	Georges/Nantucket	132	Bongo
1989	Oct. 2-28	Delaware II	89-06(II,III)	Autumn bottom trawl	Georges/Nantucket	66	Bongo
1989	Nov. 6-16	Delaware II	89-07	Larval herring	Georges/Nantucket	119	Bongo
1989	Nov. 27-Dec. 16	Delaware II	89-09	Larval herring/sand lance	Georges/Nantucket	125	Bongo
1990	Jan. 4-17	Delaware II	90-01	Larval herring/sand lance	Georges/Nantucket	178	Bongo

[1]Supplemented by H195 stations.

Table 2C. Canadian spring research bottom trawl.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1986	Mar. 3-13	Needler	N059	Spring groundfish survey	Georges Bank	79	Western IIA
1987	Mar. 9-19	Needler	N077	Spring groundfish survey	Georges Bank	70	Western IIA
1988	Feb. 29-Mar. 14	Needler	N097	Spring groundfish survey	Georges Bank	134	Western IIA
1989	Feb. 22-Mar. 7	Needler	N116	Spring groundfish survey	Georges Bank	116	Western IIA
1990							

Table 2D. U.S. spring research bottom trawl.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1968		Albatross IV	68-03,4	Spring bottom trawl			Yankee 36 OT
1969		Albatross IV	69-02	"			"
1970		Albatross IV	70-03	"			"
1971		Albatross IV	71-01	"			"
1972		Albatross IV	72-02	"			"
1973		Alb IV/Del II	73-03	"			"
1974		Albatross IV	74-04	"			"
1975		Albatross IV	75-03	"			"
1976		Alb IV/Del II	76-02,05	"			"
1977		Alb IV/Del II	77-02,03	"			"
1978		Albatross IV	78-04	"			"
1979		Alb IV/Del II	79-03,04	"			"
1980		Alb IV/Del II	80-03,02	"			"
1981		Delaware II	81-02	"			"
1982	Mar. 8-May 8	Delaware II	82-02	"			"
1983	Mar. 7-May 6	Albatross IV	83-03	"			"
1984	Feb. 29-Apr. 27	Albatross IV	84-02	"			"
1985	Feb. 25-Apr. 13	Albatross IV	85-02	"			"
1986	Mar. 3-Apr. 27	Albatross IV	86-02	"			"
1987	Mar. 23-May 5	Albatross IV	87-01	"			"
1988	Mar. 22-Apr. 15	Albatross IV	88-02(II,III)	"	Georges Bk/Nantuc./GofM	157	"
1989	Feb. 27-Apr. 13	Delaware II	89-02	"			

Table 2E. U.S. autumn research bottom trawl.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1963		Albatross IV	63-7	Autumn bottom trawl	NS-Hudson Canyon		Yank 36 OT
1964		Albatross IV	64-13	"	"		"
1965		Albatross IV	65-14	"	"		"
1966		Albatross IV	66-14	"	"		"
1967		Albatross IV	67-20,21	"	NS-Cape Hatteras		"
1968		Albatross IV	68-17	"	"		"
1969		Albatross IV	69-11	"	"		"
1970		Alb IV/Del II	70-6,7	"	"		"
1971		Albatross IV	71-6	"	"		"
1972		Albatross IV	72-8	"	"		"
1973		Albatross IV	73-8	"	"		"
1974		Albatross IV	74-11	"	"		"
1975		Alb IV/Del II	75-12,17	"	"		"
1976		Albatross IV	76-09	"	"		"
1977		Albatross IV	77-12	"	"		"
1978		Delaware II	78-06	"	"		"
1979		Alb IV/Del II	79-12,10	"	"		"
1980		Delaware II	80-07	"	"		"
1981		Del II/Alb IV	81-06,13	"	"		"
1982	Sept. 13-Nov. 12	Albatross IV	82-11	"	"		"
1983	Sept. 12-Nov. 10	Albatross IV	83-08	"	"		"
1984	Sept. 10-Nov. 9	Albatross IV	84-08	"	"		"
1985	Sept. 9-Nov. 16	Albatross IV	85-08	"	"		"
1986	Sept. 13-Nov. 6	Albatross IV	86-05	"	"		"
1987	Sept. 10-Nov. 6	Albatross IV	87-07	"	Georges Bk/Nantuc./GofM	146	"
1988	Sept. 23-Oct. 28	Albatross IV	88-09(II,III)	"	Georges/Nantucket	141	"
1989	Oct. 2-28	Delaware II	89-06(II,III)				

Table 2F. Other cruises.

Year	Date	Vessel	Cruise	Focus	Area	Sets	Gear
1984	June	Needler	N029				
1985	Oct. 25-Nov. 6	Wieczno	85-02	Herring/butterfish	Georges - northern edge and eastern tip	15	Polish trawl
1986	May 17-20	Lady Melissa		Herring	Georges northern edge	2	Purse seine
1986	Oct. 2-Nov. 5	Needler	N071	Groundfish acoustics	Eastern tip of Georges	37	Western IIA
1987	Mar. 23-Apr. 3	Lady Hammond	H169	Larval gadid	Eastern Georges	37	Mininess
1988	June 13-30	Needler	N104	Juvenile gadid	Georges	84	IYGPT

Table 3a. Results of Canadian larval herring survey of Georges Bank, Nov. 1988 (H 195).

Stratum	Sets	Larvae · m^{-2} Mean	SD	Stratum total (nos.)
1	3	0.09	0.16	8.95×10^{7}
2	3	4.59	7.82	4.52×10^{9}
3	4	10.71	11.93	1.05×10^{10}
4	3	9.88	14.49	9.73×10^{9}
5	4	9.23	11.62	9.09×10^{9}
6	3	4.57	6.84	4.50×10^{9}
7	5	11.72	7.82	1.15×10^{10}
8	5	11.30	3.35	1.11×10^{10}
9	3	8.72	3.28	8.58×10^{9}
10	3	10.31	7.68	1.02×10^{10}
11	3	0.22	0.17	2.16×10^{8}
12	3	0.07	0.06	7.21×10^{7}
13	3	17.55	18.57	1.72×10^{10}
14	3	1.52	1.38	1.49×10^{9}
15	3	0.71	1.11	6.94×10^{8}
16	3	0.07	0.11	6.53×10^{7}
17	3	0	-	
18	3	0	-	
Total area	60	6.16	9.01	1.21×10^{11} $\pm 4.58 \times 10^{10}$ (95% CI)

Table 3b. Results of Canadian larval herring survey of Georges Bank, Nov. 1989 (H 207).

Stratum	Sets	Larvae · m^{-2} Mean	SD	Stratum total (nos.)
1	5	9.23	16.87	9.09×10^{9}
2	5	4.25	8.02	4.18×10^{9}
3	6	2.75	3.58	2.71×10^{9}
4	8	0.16	0.25	1.57×10^{8}
5	6	0.09	0.02	8.86×10^{7}
6	4	0.00		0
7	6	40.32	46.32	3.97×10^{10}
8	5	12.88	5.36	1.27×10^{10}
9	3	0.81	1.16	7.97×10^{8}
10	4	0.16	0.31	1.58×10^{8}
11	6	0.11	0.22	1.08×10^{8}
12	4	0.00		0
13	4	5.47	10.70	5.39×10^{9}
14	4	0.26	0.48	2.56×10^{8}
15	5	0.02	0.04	1.97×10^{7}
16	3	0.04	0.07	3.94×10^{7}
17	3	0.00		0
18	4	0.00		0
Area total	85	4.93	16.13	8.74×10^{10} $\pm 3.10 \times 10^{10}$ (95% CI)

Table 4. Summaries of the occurrence of herring in groundfish trawl surveys.

Table 4a. Canadian spring cruises on Georges Bank, 1986-89.

Year	Cruise	Date	Stratum	Total no. sets	No. sets with herring	Total no. herring	No./ set (N)	No./ set (N^h)	Strat. mean no./set	S.E.
1986	N059	3-13/03	5Z2/5Z5*	61	19	785*	12.87	41.32	-	-
1987	N077	9-19/03	5Z2/5Z7	51	10	63.87	1.25	6.39	1.20	0.72
1988	N097	29/02-14/03	5Z2/5Z7	98	22	366.88	3.74	16.68	4.41	2.19
1989	N116	22/02-7/03	5Z2/5Z7	89	32	5796.95	65.13	181.15	79.64	40.10

*Actual numbers (not standardized).
*ICNAF designations.

Table 4b. U.S. spring cruises on Georges Bank, 1982-89.

Year	Cruise	Date	Stratum	Total no. sets	No. sets with herring	Total no. herring	No./ set (N)	No./ set (N^h)	Strat. mean no./set	S.E.
1982	DE82-02	8/03-8/05	13,16,19 20,21,23	43	2	2.00	0.05	1.00	0.05	0.03
1983	AL83-02	7/03-6/05	"	43	5	8.00	0.19	1.60	0.17	0.07
1984	AL84-02	29/02-27/04	"	44	10	50.00	1.14	5.00	0.85	0.31
1985	AL85-02	25/02-13/04	"	41	15	203.00	4.95	13.53	4.06	1.95
1986	AL86-02	3/03-27/04	"	42	10	179.00	4.26	17.90	3.03	2.00
1987	AL87-01	23/03-5/05	"	43	7	35.00	0.81	5.00	0.51	0.34
1988	AL88-02	5/03-21/04	"	42	2	6.00	0.14	0.33	0.13	0.09
1989	DE89-02	27/02-13/04	"	42	10	131.00	3.12	13.10	2.79	2.25

Table 4c. U.S. fall cruises on Georges Bank, 1982-88.

Year	Cruise	Date	Stratum	Total no. sets	No. sets with herring	Total no. herring	No./ set (N)	No./ set (N^h)	Strat. mean no./set	S.E.
1982	AL82-11	13/09-12/11	13,16,19 20,21,23	42	4	8.00	0.19	2.00	0.13	0.09
1983	AL83-08	12/09-10/11	"	42	1	1.00	0.02	1.00	0.04	0.03
1984	AL84-08	10/09-9/11	"	42	1	19.00	0.45	19.00	0.39	0.39
1985	AL85-08	9/09-16/11	"	41	3	6.00	0.15	2.00	0.12	0.06
1986	AL86-05	13/09-6/11	"	42	5	122.00	2.90	24.40	1.52	0.70
1987	AL87-07	10/09-6/11	"	44	9	602.00	13.68	66.89	10.54	8.59
1988	AL88-09	23/09-28/10	"	43	19	1729.00	40.21	91.00	29.65	20.35

Table 5. Details of samples compared in a northwest Atlantic herring stock identification project; 1985-87

Assmt. Unit	Spawning Group	Month Collected	1985			1986			1987		
			Male	Female	Total	Male	Female	Total	Male	Female	Total
3L	Bonavista Bay	May				1	44	45			
4T	Escuminac	May	47	56	103	53	45	98			
4V	Bras D'or Lake	May	47	54	101	55	28	83			
4W	Western Bank	Oct				57	54	111			
4X	German Bank	Sept	47	51	98	50	50	100			
	Trinity Ledge	Aug	50	51	101	50	61	111			
		Sept				2	99	101			
	Parrsboro	May	76	59	135	53	52	105			
	Ile Haute	July	41	59	100	51	56	107			
	Grand Manan	Sept	49	61	110	50	59	109			
5Y	Cutler	Aug/Sept	50	54	104	111	78	189			
	Jeffries Ledge	Oct							119	131	250
	Nauset Harbour	Nov							64	58	122
5Z	Georges Bank	Oct				20	13	33			
		Nov				53	56	109	232	164	396
Total Numbers of Fish			407	445	852	606	695	1301	415	353	768

Table 6. Summary of attributes compared in a northwest Atlantic herring stock identification project.

Category	Attribute
Morphology	Fish shape analysis based on 15 truss point locations.
Meristics	Vertebral count, fin ray counts - pectoral, pelvic, dorsal, anal; gill raker count; pyloric caecae count.
Parasites	Nematodes - *Anisakis simplex* and *Hysterothylacium aduncum*; Digenea - *Derogenes varicus, Brachyphallus crenatus, Lecithaster* spp.; Acanthocephala - *Echinorhynchus gadi*; Cestoda - *Scolex pleuronectis.*
Otolith morphology	Fourier shape analysis - based on nucleus as origin and 72 points around the shape periphery (every 5 degrees). Truss analysis based on 22 point locations.
Genetics	Mitochordrial DNA and electrophoresis (PGI-2, LDH-2, PGM-2) on a limited subsample.

Table 7. Means and standard errors for meristic characters of GeorgesBank and neighboring Atlantic herring populations.

Location	Date	Sample size	Vertebrae count	Pectoral fin rays	Pelvic fin rays	Dorsal fin rays	Anal fin rays	Raker count	Caecal count
Georges Bank	Oct. 29/86	142	55.60±0.08	19.19±0.06	10.16±0.03	19.92±0.06	17.92±0.06	49.23±0.13	24.36±0.22
	Nov. 7/87	396	55.59±0.03	19.14±0.04	10.18±0.02	19.91±0.03	17.99±0.04	48.90±0.08	24.40±0.14
Nauset Harbour	Nov. 3/87	122	55.56±0.04	19.13±0.07	10.18±0.04	19.83±0.06	17.95±0.08	48.98±0.12	24.89±0.25
Jeffries Ledge	Oct. 26/87	250	55.67±0.06	19.29±0.04	10.14±0.02	19.99±0.04	18.07±0.05	49.13±0.10	24.80±0.19
Trinity I	Aug. 27/86	111	55.60±0.06	19.43±0.07	10.07±0.03	19.95±0.06	18.08±0.08	49.05±0.17	24.65±0.28
Trinity II	Sept. 29/86	101	55.44±0.07	19.29±0.07	10.15±0.07	19.86±0.07	17.94±0.08	49.27±0.14	24.37±0.25

*Groups significantly different at the 0.05 level - comparisons restricted to samples collected in the same year.

Table 8. Percentage prevalence (P), mean intensity (I) and abundance (A) of *Anisakis simplex, Hysterothylacium aduncum, Brachyphallus crenatus, Derogenes varicus, Lecithaster* sp. and *Scolex pleuronectis* collected from spawning herring 'stocks' (stage 6 except for Jeffries Ledge and Nauset Harbour) 1985/87. P: number of individuals of a host species infected with a particular parasite divided by number of hosts examined; I: total number of individuals of a particular parasite species in a sample of a host species divided by number of infected individuals of the host species in the sample; A: total number of individuals of a particular parasite species in a sample of hosts divided by total number of individuals of the host species (infected and uninfected) in the sample.

Area	Date collected	No.of fish	Mean length (mm)	SD	A. simplex P	A. simplex I	A. simplex A	H. aduncum P	H. aduncum I	H. aduncum A	B. crenatus P	B. crenatus I	B. crenatus A	D. varicus P	D. varicus I	D. varicus A	Lecithaster sp. P	Lecithaster sp. I	Lecithaster sp. A	S. pleuronectis P	S. pleuronectis I	S. pleuronectis A
Trinity Ledge	Aug. 27/86	111	274	20	13.0	2.5	0.3	14.0	1.2	0.2	83.0	3.8	3.1	10.0	1.2	0.1	8.0	2.4	0.2	0.0	0.0	0.0
	Sep. 29/86	101	295	32	28.0	3.1	0.9	19.0	1.2	0.2	89.0	9.4	8.4	12.0	1.1	0.1	16.0	1.9	0.3	0.0	0.0	0.0
Georges Bank	Nov. 7-9/87	396	262	25	18.2	1.7	0.3	10.6	1.1	0.1	86.6	3.8	3.3	0.1	1.1	0.1	4.8	1.3	0.1	0.1	1.4	0.1
Jeffries Ledge	Oct 26/87	250	306	13	6.8	1.5	0.1	5.2	1.2	0.1	73.2	2.8	2.0	6.8	1.1	0.1	1.6	1.8	<0.1	0.0	0.0	0.0
Nauset Harbour	Nov. 3/87	122	278	10	13.1	1.6	0.2	7.4	1.3	0.1	73.8	2.8	2.1	3.3	1.0	<0.1	2.5	1.0	<0.1	0.0	0.0	0.0

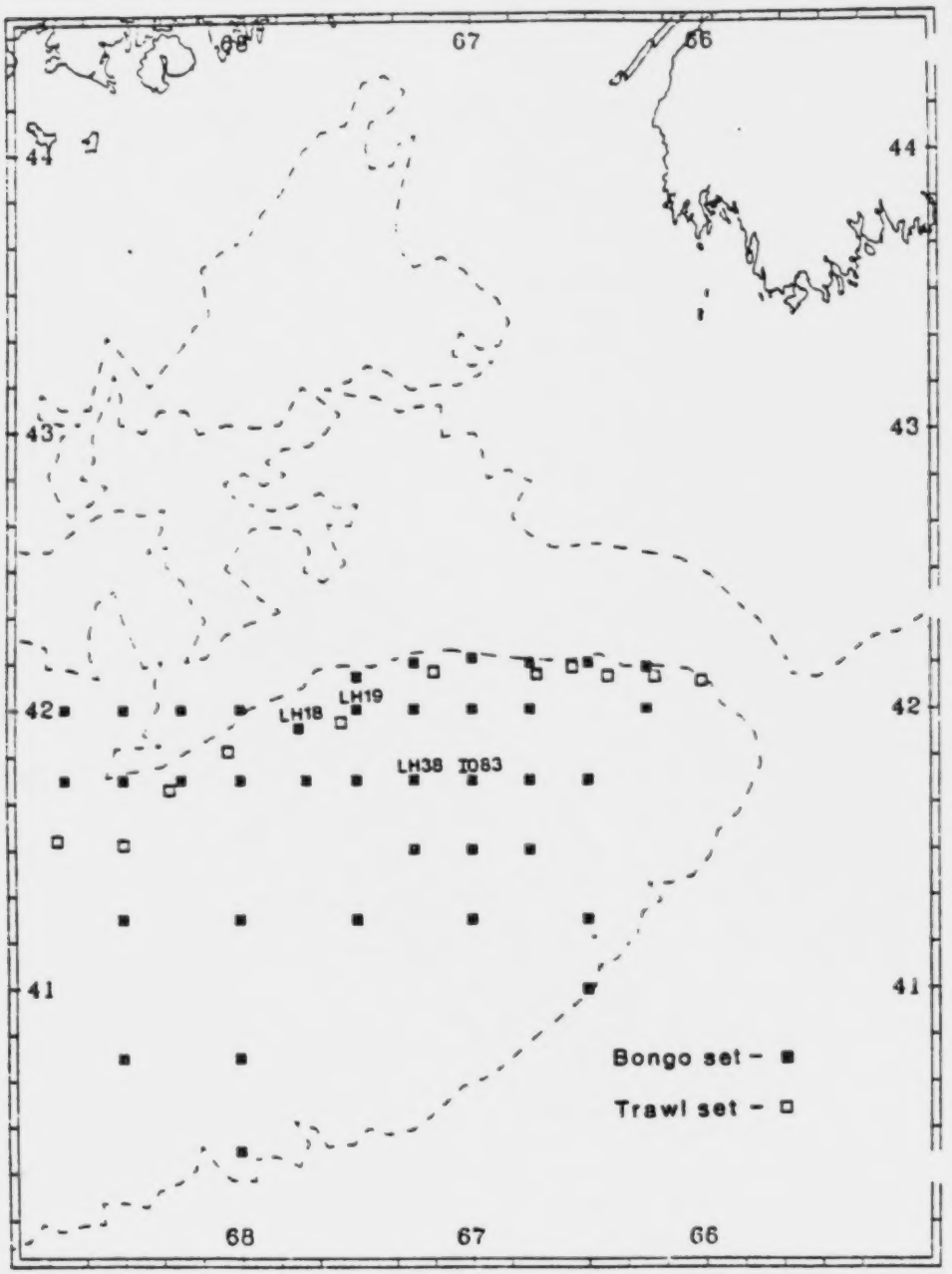

Fig. 1a. Location of bongo and ground trawl sets on Canadian autumn Georges Bank herring survey H181, 1987.

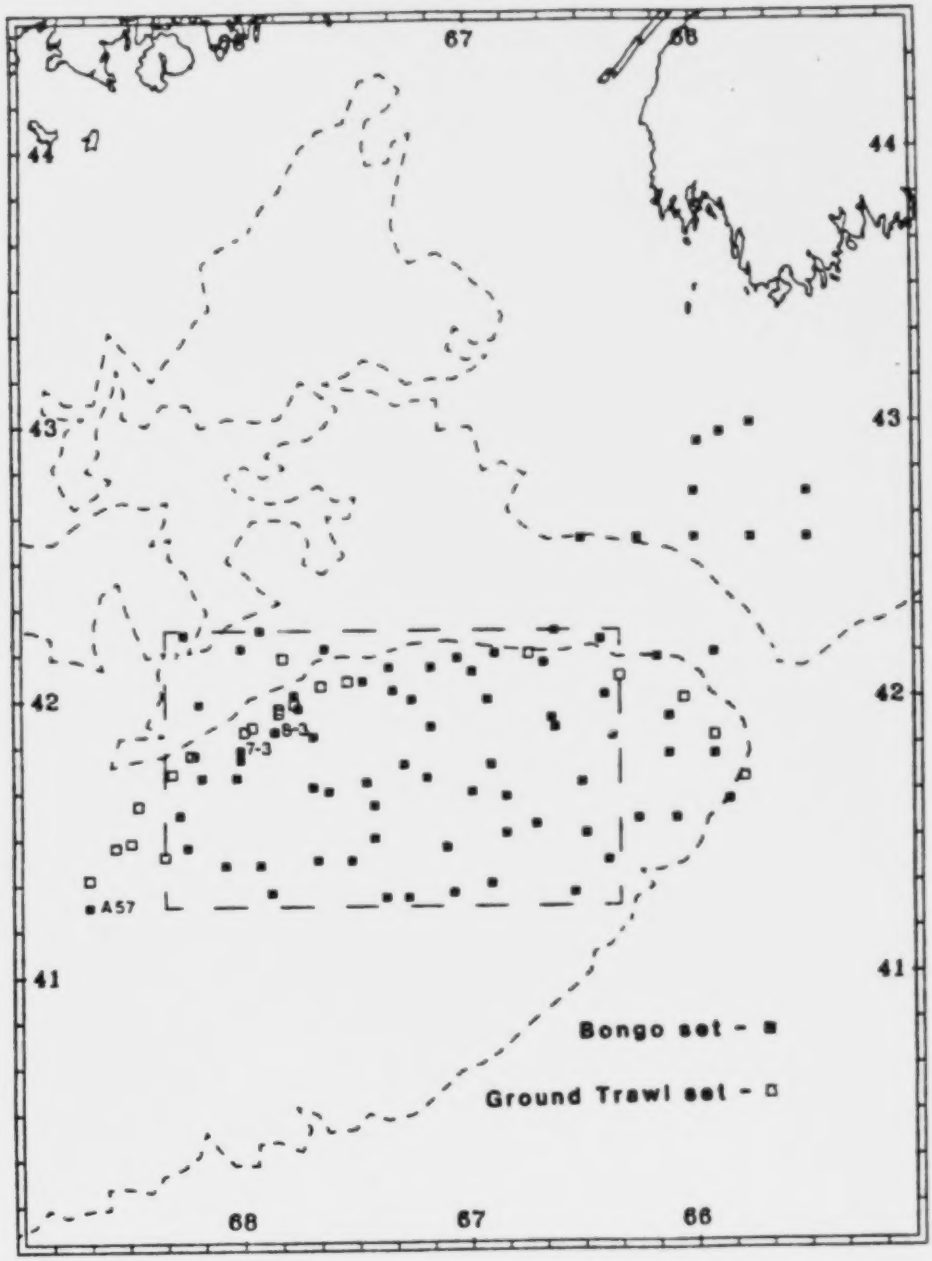

Fig. 1b. Location of bongo and ground trawl sets on Canadian autumn Georges Bank herring survey H195, 1988.

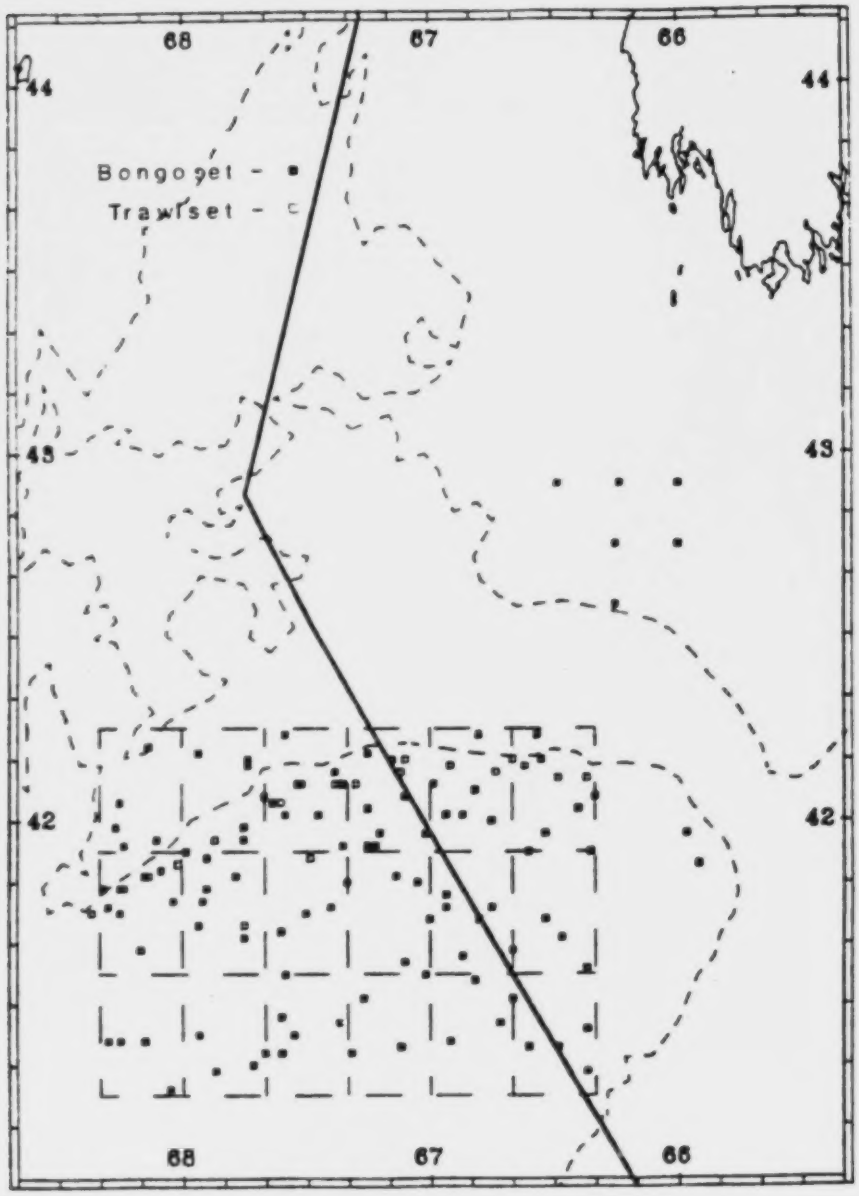

Fig. 1c. Location of bongo and ground trawl sets on Canadian autumn Georges Bank herring survey H207, 1989.

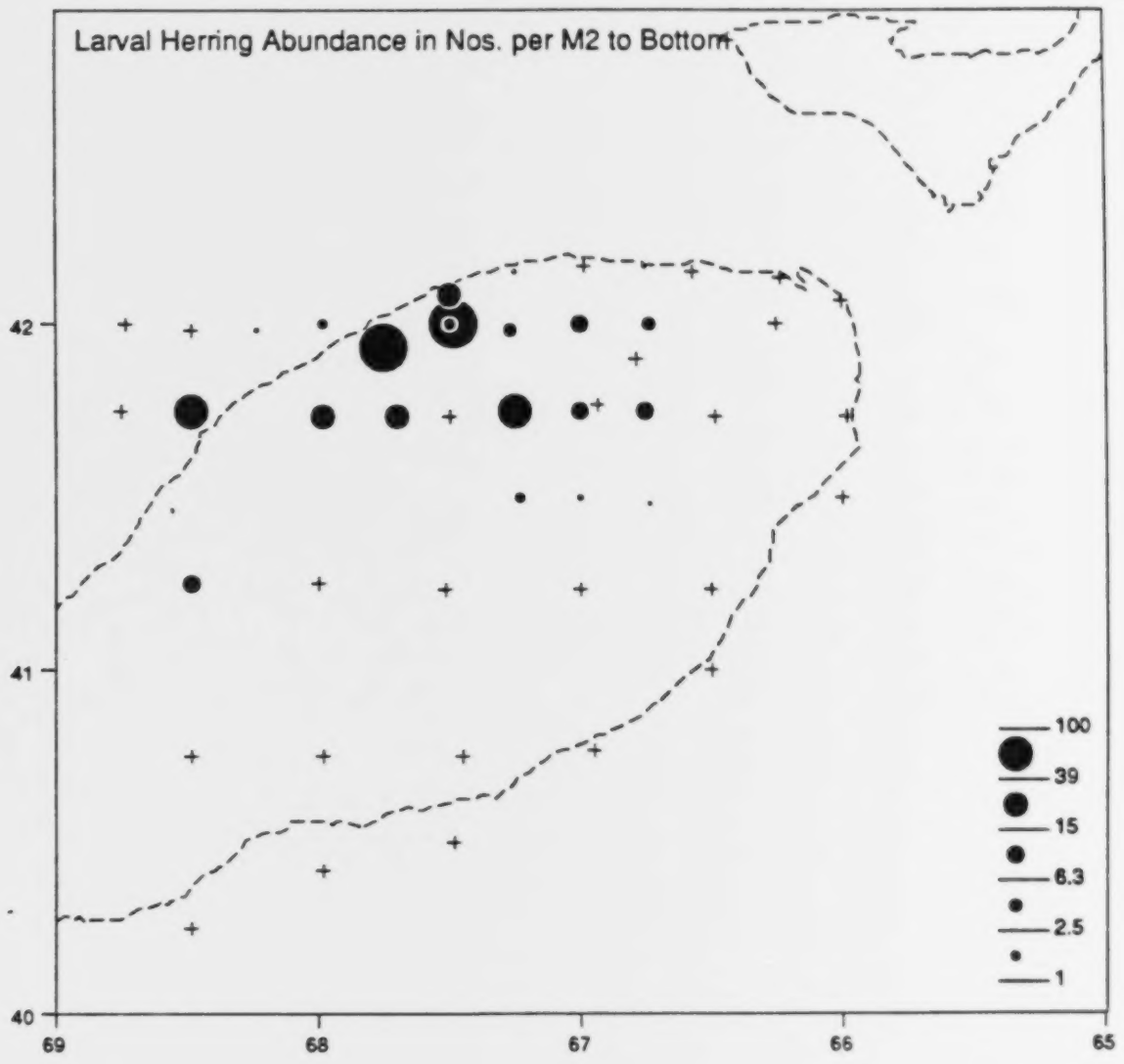

Fig. 2a. Larval herring abundance (no. m^{-2}) from Canadian autumn Georges Bank herring survey H181, 1987.

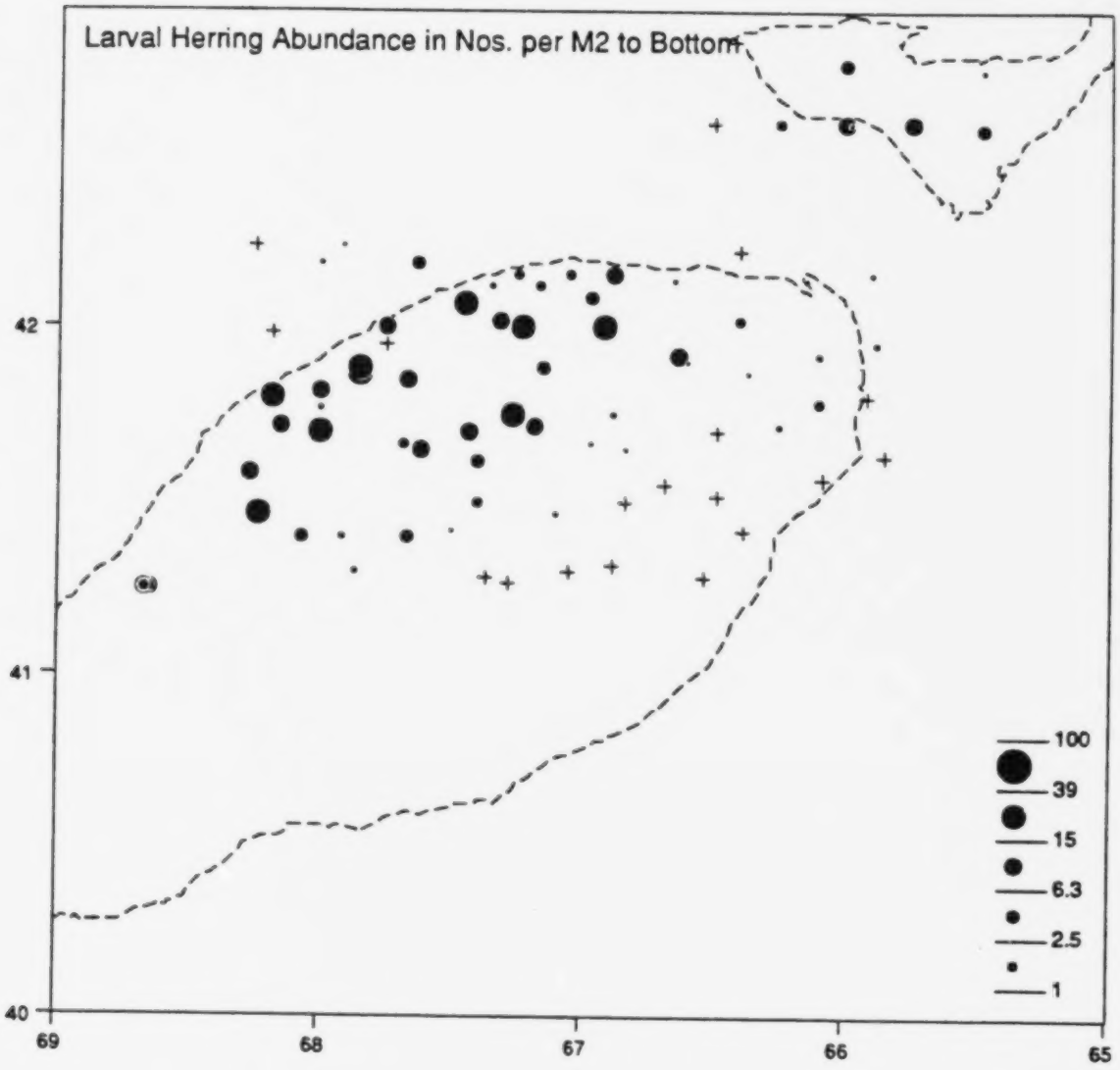

Fig. 2b. Larval herring abundance (no. m^{-2}) from Canadian autumn Georges Bank herring survey H195, 1988.

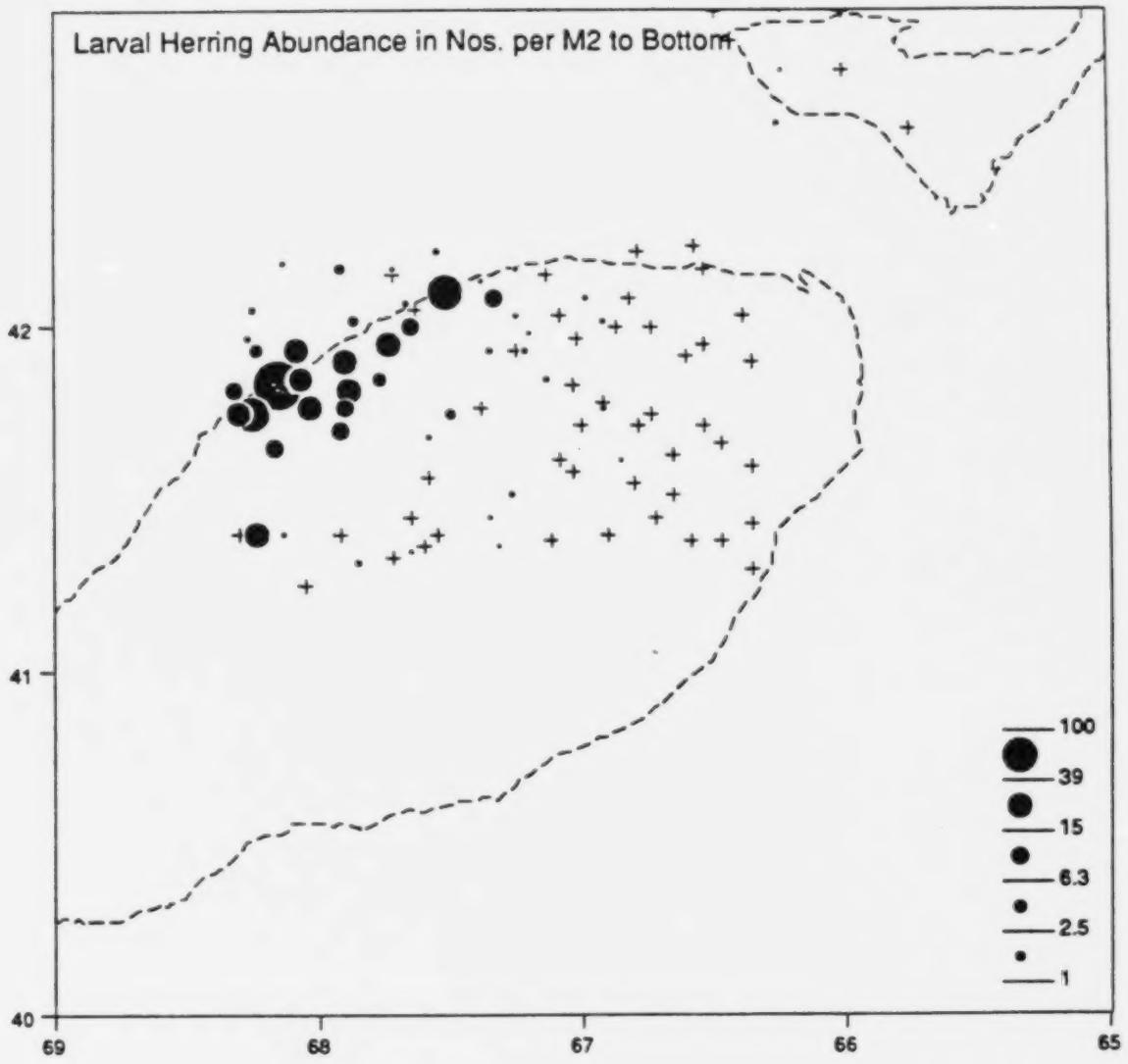

Fig. 2c. Larval herring abundance (no. m^{-2}) from Canadian autumn Georges Bank herring survey H207, 1989.

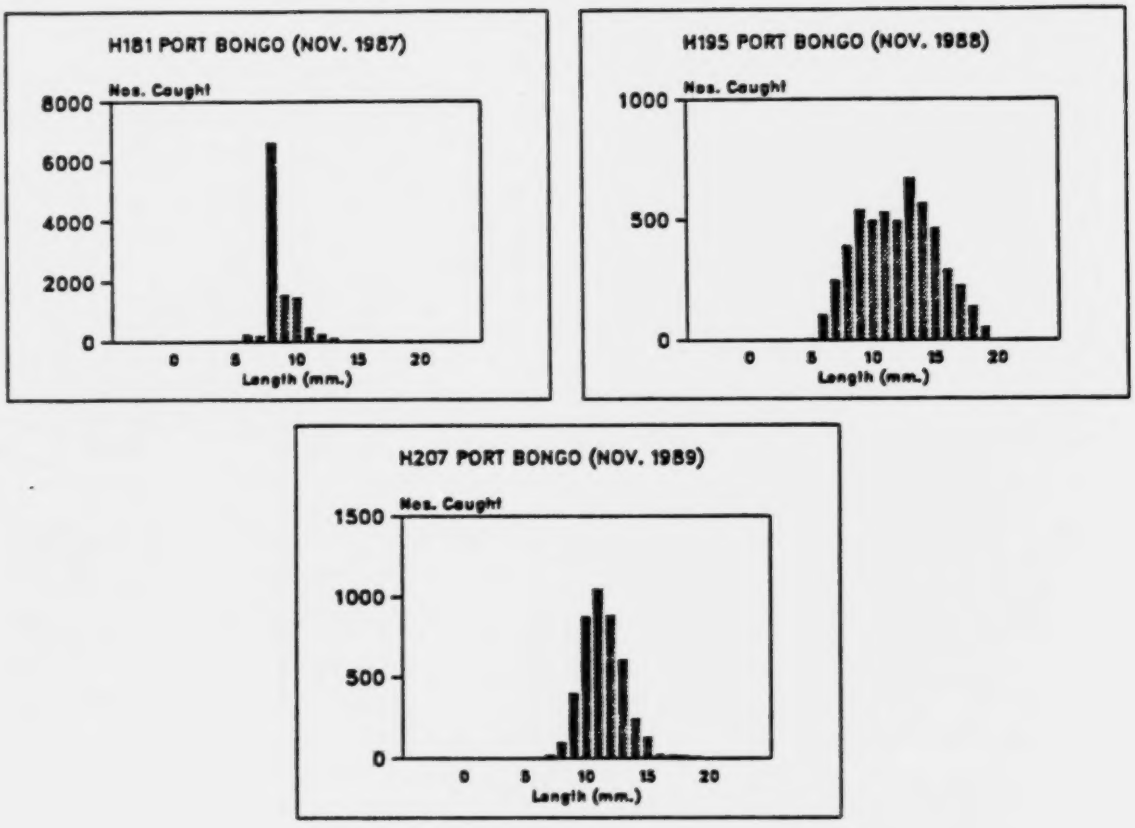

Fig. 3. Length frequency distribution of larval herring from Canadian surveys of Georges Bank in Nov. 1987 (H181), Nov. 1988 (H 195) and Nov. 1989 (H 207).

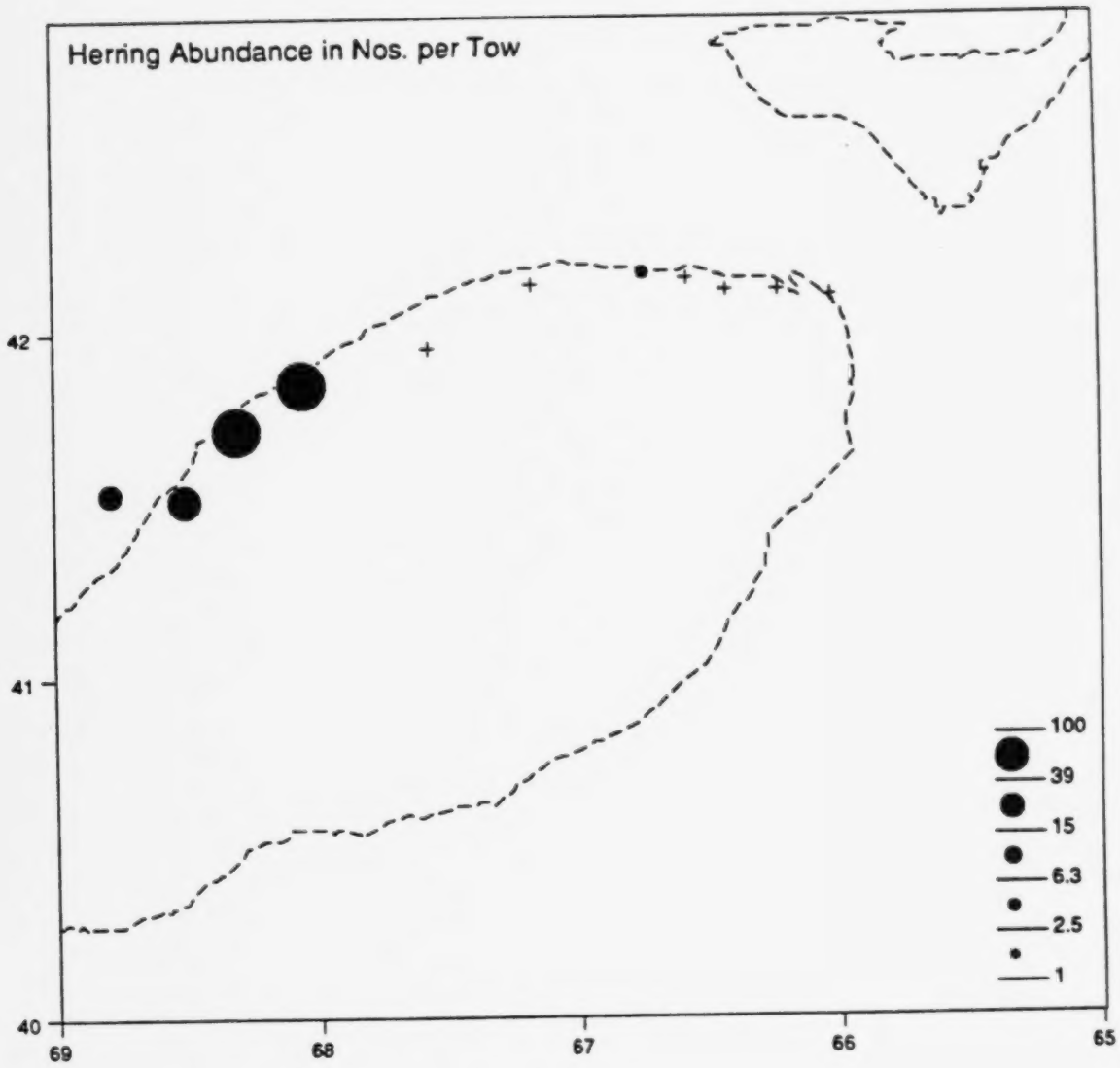

Fig. 4a. Catches of adult herring (number/tow) in ground trawl sets of the 1987 Canadian Georges Bank herring survey (H 181).

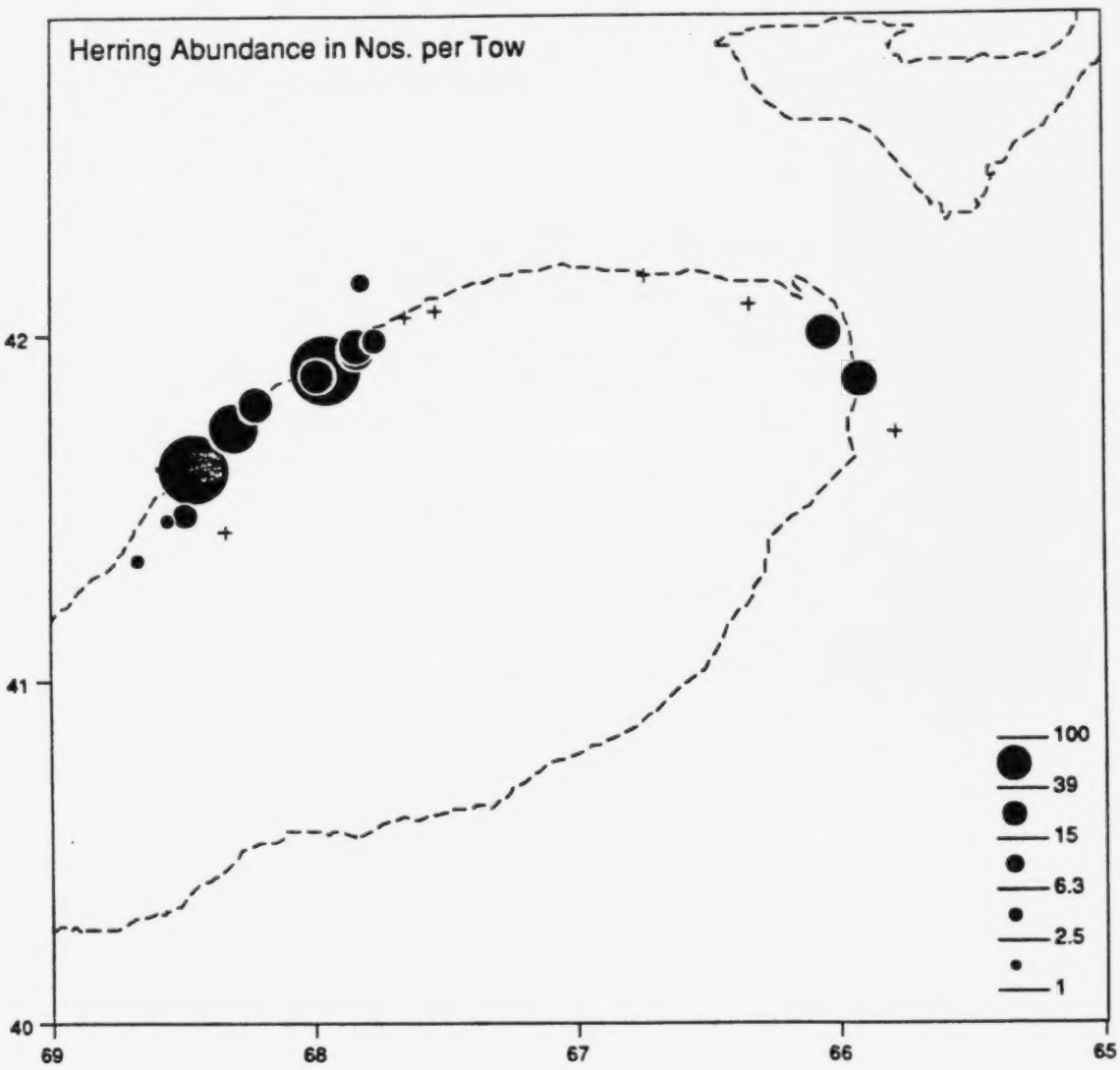

Fig. 4b. Catches of adult herring (number/tow) in ground trawl sets of the 1988 Canadian Georges Bank herring survey (H 195).

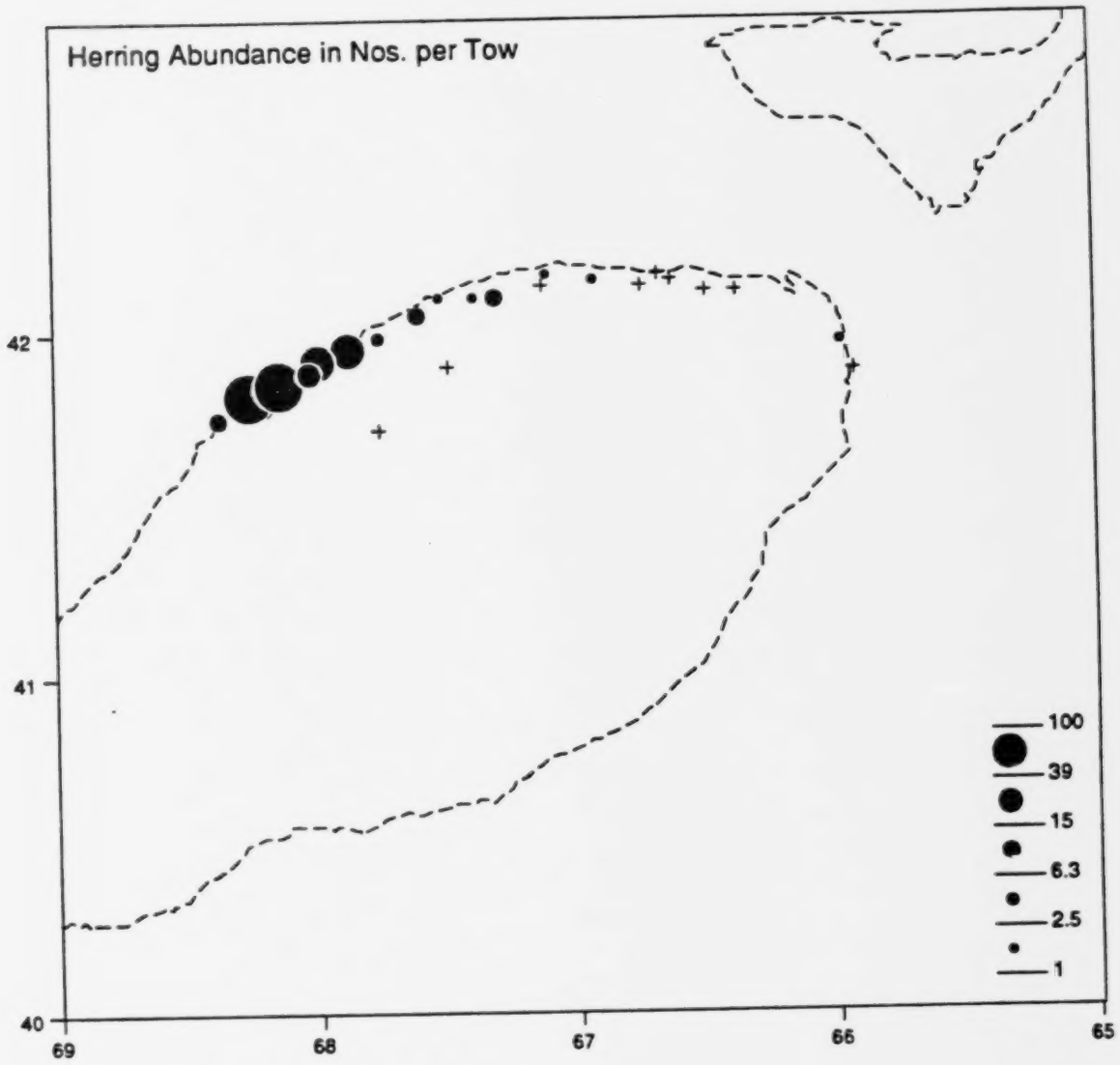

Fig. 4c. Catches of adult herring (number/tow) in ground trawl sets of the 1989 Canadian Georges Bank herring survey (H 207).

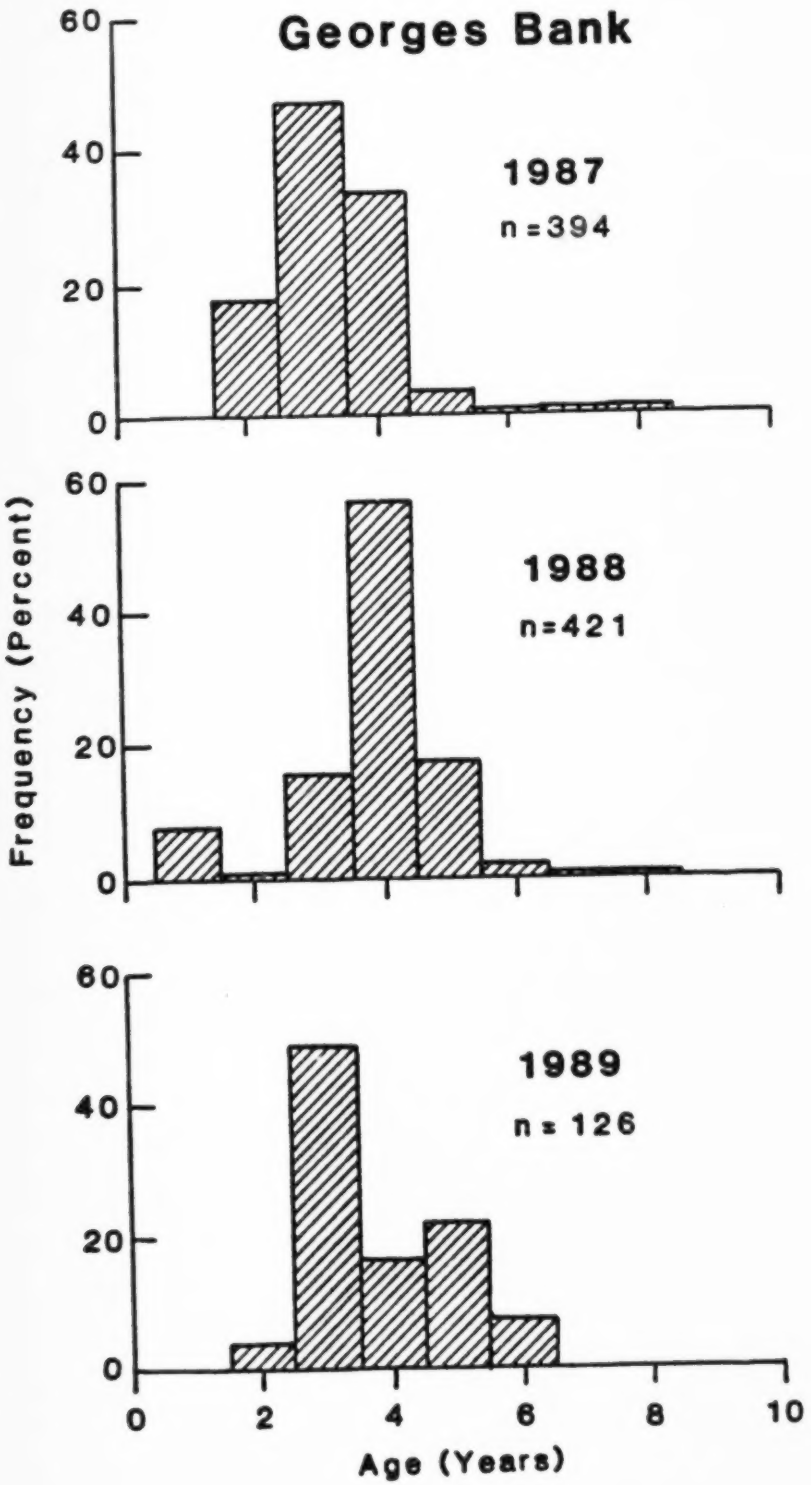

Fig. 5a. Age composition of Georges Bank herring derived from ground trawl data collected on Canadian autumn Georges Bank herring surveys, 1987-89.

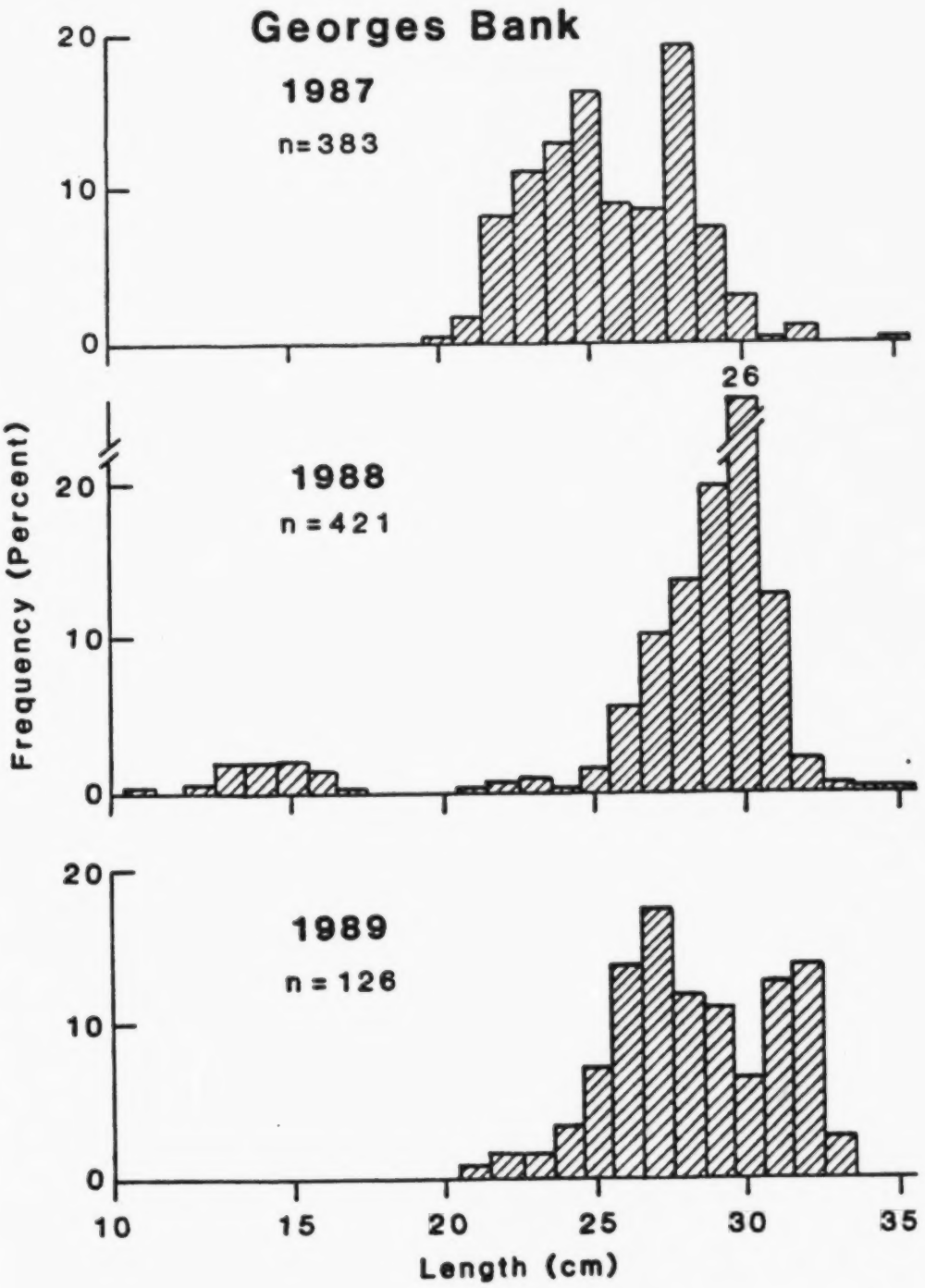

Fig. 5b. Size composition of Georges Bank herring derived from ground trawl data collected on Canadian autumn Georges Bank herring surveys, 1987-89.

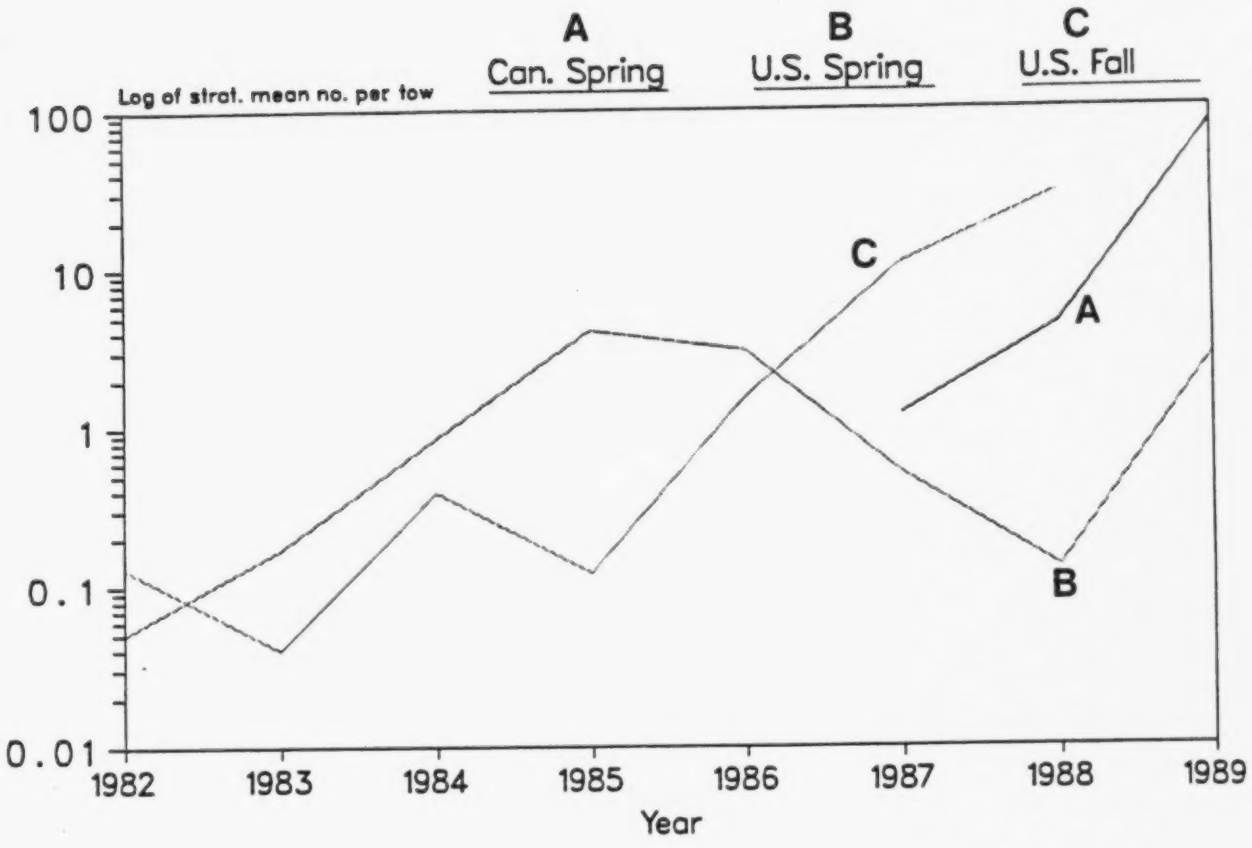

Fig. 6. Herring bycatch in groundfish trawl surveys.